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Human-centered design curriculum for multidisciplinary application at design faculties

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Abstract

Human Factors was first established as a primarily psychological discipline. In later years, Human-Centered Design (HCD) expanded into a sophisticated engineering discipline and business sciences increasingly came to recognize its relevance. At the same time, while designers have always played a vital role in the field in the last decades, they usually have not had a scientific education. In order to truly work together in a multidisciplinary fashion, it is necessary for design faculties to recognize the importance of HCD. Today, professional knowledge is mainly gathered through learning-by-doing across disciplines. The following article describes an approach towards a curriculum of HCD at a design faculty to be applied in multidisciplinary environments. In the context of the article, the key aspect is the collaboration between disciplines, allowing students and professionals from the fields of psychology, information technology, business administration and design to work together more seamlessly and effectively. In addition to an outline of the research field and the structure of the curriculum, the focus will be on first-term courses with a view to specialization in later terms.

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1. Purpose, methodology and research

The purpose of this article is to provide a draft of a curriculum for Human-Centered Design (HCD) to be applied at design faculties with applicability in disciplines such as psychology, information technology, business administration or other fields of study. As methodology to develop this curriculum, several sources were taken into account. The international standard ISO 9241[1], describing guidelines of Human-Computer Interaction (HCI), and the information provided by the German national accreditation body[2]are used for definition, coherences, structure and a general framework. In addition, research of exemplary Human-Computer Interactioncurricula in the fields of psychology & human factors, information technology, business administration, designand related studies has been conducted [3,4,5,6,7]. As a prerequisite of the following curriculum sketch, the general objective for designers is defined as being the creation of the best possible human experiences, no matter whether the humaninvolvedis a consumer, a user or some other contextually relevant person. In order to shape an interaction between humansand computers, the curriculum as sketched out below uses Human-Centered Design[8]as an integral factor. Accordingly, the integration of knowledge sharing and practical execution and thereby the experience of the approach, activities and methods of Human-Centered Design is at focus.

In the first term, an overview in relation to HCI is provided, followed by in-depthexamination of HCD activities in the following terms: Prototyping (term 2), user research (term 3), usability evaluation (term 4) and usability engineering (term 6).

2. Outline for a curriculum for HCD at a design faculty – Term 1

2.1. Term overview

The first term provides a general introduction to Human-Centered Design from two angles: Firstly, HCD terminologies, approach and methods are described. Secondly, the methods are tried out in practical exercises. Thetwo approaches are combined,each lesson consisting of a theoretical and a practical segment. Thus the whole term follows the process of experiential learning [9]. The structure of the first term follows an idealizedapplication of the Human-Centered Design approach without reference to any software development lifecycle. The starting point is the activity of understanding and specifying the context of use, followed by the specification of the user requirements with reference to design thinking activities. At a later stage, students are required to put their acquired knowledge into practice by producing their own design solutions; these are then evaluated and improved accordingly. In the end, the students will have learned about the foundations of HCD in both a theoretical and a practical way. The details of the twelve lessons are listed in the following sections.

2.2. Introduction to Human-Centered Design

Lesson one of the first term provides the early semester students with an introduction to the topic, the basic terminologies, a delineation of the practical semester work and an overview of the lessons to follow. After showing a few basic examples of various current digital consumer experiences, the connecting factor is explained: everything in this course is related to the interaction between humans and computers. “Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them” [3]. In accordance with the examples shown, a comparison with customer experiences is drawn, which is described as the sum of all the experiences a person has at all touch points with a service, product or system.

In the actual lesson, the students are asked to sketch an idea for an app in accordancewith a bogus but prototypical agency briefing (“The customer, a leading coffee shop chain, requires an app optimized for the iPhone for customer relationship purposes. Please come up with an idea!”). They are required to illustrate their idea ina series of four sketches, the whole to be completed within ten minutes, and are then given the opportunity to present their results to the group. Following this, the briefing is analyzed in the group, questioning the contextual background and the actual purpose of the briefing. The aim of this exercise is to learn not to jump into creating a solution for something that is not fully understood. This something is explained as the sum of characteristics of the

user, her task, the system and the context of use – all impacting the user's experience (UX). In connection with this, the structure of an information system is described as the human take on a system, not the technical view of it[10]. As an aid to understanding the context and achieving a good user experience, the concept of taking into account the human view of an information system is introduced as Human-Centered Design.

Human-Centered Design is defined as "an approach to interactive systems development that aims to make systems usableand useful by focusing on the users, their needs and requirements, and by applying humanfactors/ergonomics, and usability knowledge and techniques" [8]. At its core, it is about understanding people, their context and their needs. Throughout design and development, it is essential to involveactual users. The people involved in the approach need to have a mindset to address the entire experience and to take multidisciplinary perspectives. The approach of HCD is split into various activities: plan the Human-Centered Design process, understand and specify the context of use, specify the user requirements, produce design solutions to meet user requirements and evaluate the designs against requirements. After passing through several iterations, the design solution meets the user requirements. The transferability of the approach to other disciplines of the design field is mentioned to the first-term students: When creating other kinds of non-interactive or analogous communication media, the basic principles also apply to designing ads, movie trailers or magazine illustrations.

From this point on, HCD is to be understood as the connecting link between all following lessons as well as the following terms. In the remaining lessons in this semester, HCD is explained step by step, introducing each activity and several methods. From these, various selected methods will be used for practical group exercises and are explained as components of the following lessons. As overarching theme for the practical exercises in the first term, the general task is to create a "concept of an interactive system for students". This task is deliberately broadly defined and unspecific as the idea is to run through an ideal HCD cycle while having the students phrasing their own statement of the problem in the course of the term.

2.3. Understand and specify the context of use. Exercises: Personas, diary and storyboard

After having introduced the term "user experience" in lesson one, the term is now defined according to ISO 9241:210as a "person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service"[8]. Factors used to describe the user experience are taken from an approach called "holistic user experience" (HUX), for example the product's functionality, interactivity, screen design, packaging, material quality, performance, smell, etc. [11].In addition, the user's experience is described as the sum of the experiences that a user has before, during and after use.The user's mental model is mentioned as an influencing factor before use, depending on the previous experiences that the user had with similar services or products or with the same company or brand but in a different context. After use, the user will consciously or subconsciously reflect on the experience with the product or service which will influence the effect of the experience and will eventually change the mental model for further scenarios to the good or the bad. During use, the actual usage and with it the usability plays the main role. Usability is defined as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"[12].

Referring back to lesson one, the first HCD activity (understand and specify the context of use) is described further. Examples from various contexts are given by way of illustration, such as the scenario of a woman in a shopping center, using the visitor information panel alone / with husband and kid / with friends; or the placement of a car park ticketing machine separately / in a gloomy place / next to a public transport ticketing machine. Building upon these examples, the difference between consciously expressed wishes and users' actual needs is made clear. The idea is not to fulfill the list of wishes of people who are asked to phrase how they would see an improved solution but to understand the user's actual situation, background, tasks, goals and needs. Several methods of how to understand and specify the context of use are described: Focus groups, contextual inquiries resp. interviews, observations[13], diaries[14] and personas [15].

Personas are used in order to achieve a change in perspective and function as basis of discussion. They give each user group a face and archetypically represent it. Usually, personas consist of demographic data (name, age, nationality, photo), social data and characteristics (interests, motivation, favorite products/services/brands) and context-specific data (technology affinity, device usage, study path). In a practical exercise, the students are asked to

write down all characteristics and specific information about a fictitious student of theirown invention and are then asked to pick one as distinguishing factor, for example study path or motivation level,in order to define user groups. For each user group, the task is to create at least one representative persona. At the end of the lesson, the students are asked to use the diary method on themselves by documenting their student life for a week.

In lesson three, an analogy is drawn between a regular human dialog and a Human-Computer Interaction. Acquired behavior and general conventions in social life are usually not projected in an HCI dialogue. An interaction with a system does not typically follow human behavior and, as a result, generally does not follow Natural Human Interaction (NHI)[16]. The need for other kinds of mental models in relation to system interaction is addressed. Referring to the above-mentioned methods to understand and analyze the context of use, the outcome of that activity is a list of user needs and a context description resp. a context scenario. The purpose of the context scenario is to document what has been analyzed in a certain format, for example a textual description, a user journey map or a storyboard.

For the practical exercise, the students are first asked to share their diary results in their respective group.As a second step, one of the personas is selected and a typical process in this persona's life (inspired by the shared diary results, for example an average day in his or her life, a specific study course or a night out with friends) is then sketched out in the format of a storyboard. Afterwards, the students are asked to present their selected persona and the storyboard.

2.4. Specify the user requirements and ideation. Exercises: "How might we", user journey map, card sorting

As the second activityin HCD, user requirements need to be specified. A user requirement is defined as a necessary user action in an interactive system, by describing the task and not the technical realization [17].Therefore, it is important to distinguish between user requirements, business requirements and technical requirements. Business requirements are taken up from the client or manager and fulfill the purpose of describing the requirements towards a solution to serve a certain business need. If, for example, the business objective of a new enterprise software solution is to raise the employee productivity by the factor of two, all business requirements need to support this objective toward a more productive user and system interaction. A technical requirement might be phrased based on certain infrastructural or architectural boundaries, the connection to other systems or certain programming languages. On top of that, there might be various other kinds of requirements, such as market, regulatory or legal requirements.

The process of deriving user requirements from the user needs is a critical activity in the correct execution of HCD. For this task, HCD does not provide much room for alternative methods, which is why for the first semester course, an excursus to Design Thinking (DT) is taken at this stage (the derivation of user requirements from the user needs according to HCD is taken up during the third semester). Design Thinking is described as "a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success" [18], "an approach for creative problem solving"[19]. The reason why DT is mentioned here is the crucial activity of ideation[20] during the process. This is seen as an alternative, more open way of getting to new solutions.

The practical exercise in lesson four is based on point of view and ideation brainstorming methods, using "How Might We" (HMW) questionsas designated by the Institute of Design at Stanford [21]. Firstly, the students are asked to identify problems and needs of the persona shown in the storyboard and to derive insights from them. Then, they are asked to phrase one HMW question and individually create five radical ideas to answer it. After briefly explaining their own ideas to the group, the students proceed to rate the collected ideas,whereby each student has two votes. A second round of creating ideas, discussing and voting follows, resulting in a single group idea.

Lesson five starts with a focus on distinguishing between the problem space and the solution space.The storyboard illustrates the as-is situation of the problem space. The next step is to sketch the to-be situation of the solution space. In this way the difference between a context scenario (as-is) and a usage scenario (to-be) is demonstrated. For creating the usage scenario, the students are reminded of the user journey maps method. Each group is asked to describe the effect of the group idea on the context scenario by representing the usage scenario in the format of a user journey map.

By means of the user journey map, interaction between the human and the computer isdepicted superficially. The next step is to think through further interactions, characteristics and features that the solution will have. The term Information Architecture (IA) is introduced as the “structural design of shared information environments”, “the combination of organization, labeling, search, and navigation systems within web sites and intranets” and “the art and science of shaping information products and experiences to support usability and findability” [22]. The next exercise is called card sorting which is a method of grouping information and developing structures with a view togenerating information architectures. The students are asked to write down all solution characteristics and features that can be deduced from the user journey map. Several rounds of card sortings are conducted within the individual groups and with students from other groups. The result is a clustering and basic hierarchy of the IA of the system.

2.5. Produce design solution to meet user requirements. Exercises: Prototyping, interactive prototyping

The IA is taken as structural foundation of the prototypic graphical realization of the solution. In order to translate a structural description into a graphical prototype, certain rules of layout and design are to be considered, which is why the Gestalt Laws[23] are referenced. The laws of proximity, similarity and closure, above all, are illustrated with examples from user interface (UI) design. Examples for changing viewpoints when looking at and using interactive systems are shown as eye-tracking recordings. The UI is described as a tool, resp. a means to enable the human and the computer to communicate and interact with one another. This user interface can be represented as a prototype in various levels of detail (low-fidelity to high-fidelity);from sketches via wireframes to visual design. At the level of low-fidelity prototypes, the focus is on structure, placement, sizing and relationships of UI components. In contrast, the high-fidelity visual design prototypes make use of colors, fonts and other graphical elements, such as shadows and gradients, to give the solution a face and character.

The next step is to make the prototype interactive. Depending on the degree of fidelity, there are various ways of doing so. One example that is used when referring to interactive low-fidelity prototypes is the “Wizard-of-Oz” method: Pen-and-paper sketched user interfaces are easily made interactive with a moderator, representing the system logic. The user points at a place on the sketched prototype and the moderator exchanges the pieces of paper, as if the system were displaying another page. For the creation of high-fidelity interactive prototypes there is a vast number of pieces of software. For the practical exercise in the first term, the students are free to make use of the “Wizard-of-Oz” method or to employ software, such as the Adobe CC [24] tools, Balsamiq[25] or Invision[26], to create interactive prototypes.

2.6. Evaluate the designs against requirements. Exercises: Usability test, finalizing the prototype

Lesson eight starts with a reference to cultural differences in human communication. Examples are given of the huge differences in simple hand signs, behavioral conventions and the translation of the same to means of communication and digital interactive systems, for example differing social media platforms in China, Russia, Brazil or the USA. The reference is drawn to break the illusion of something being “normal”. What is normal and what is not normal depends on mental models and thereby on expectations that people have towards general or specific communication and its peculiarities. Referring back to interactive systems and the definition of usability, the measuring factors are effectiveness, efficiency and satisfaction. In order to rate the efficiency, the seven dialogue principles are introduced [27]. All potential or existing usability problems can be described as a violation of at least one of the seven dialogue principles. The measuring dimensions are quality to quantity, formative to summative and user’s perspective to expert’s perspective. Qualitative evaluation is a descriptive and explorative way to test an unspecific test object with a high degree of effort, of which the results are not generalizable. In contrast, quantitative evaluation is a numeric coverage of a clearly defined test object with high generalizability and requiring a low level of effort to conduct. Formative refers to an evaluation during creation or development of the solution, resulting in recommendation for improvement, while the summative evaluation results in a conclusive rating, benchmarking the current status. Evaluation from the user’s perspective is made by observations or inquiries of actual users while in the case of evaluation from the expert’s perspective, one or more usability professionals need to understand the topic of interest, the context and the users and also need to keep to certain pre-defined rules and criteria while evaluating.

In order to rate a system, formative and summative evaluation methods with users are shown, such as quantitative questionnaires. To optimize a system with formative evaluation methods by experts, exemplary methods, such as scenario-based walkthroughs or heuristic evaluations [13]are introduced. Other methods are mentioned when optimizing a system through formative evaluation methods with the help of users. These include focus groups, qualitative questionnaires or usability tests.

A usability test is described as a test of the interactive system, not of the user, to find out about potential or actual usability problems, which are referenced to at least one dialogue principle each. In a scenario-based usability test, the users are given tasks by a moderator and are encouraged to “think aloud”, providing the moderator with more information. The non-influential role of the moderator is crucial for the correctness of the results. Usability tests can be conducted in fully equipped labs including eye-tracking technology, or in the field, for example with mobile devices or within the actual context of use. In the practical exercise, the student groups are each asked to designate one member as moderator, and one user as jumper, the rest of the group being observers. The user of one group then tests the interactive prototype created by another group,and the moderator and her observers summarize the observations.

Depending on the outcome of the usability test, the students have lesson nine to refine the prototype with reference to previously shown methods, re-evaluate it and finalize it.

2.7. Plan the Human-Centered Design process

After the students have experienced an idealized HCD cycle they are given examples of limitations and implications when practically executing HCD. Factors such as changing business requirements, development hurdles, incorrect effort estimations, stakeholder communication and the need for coordination are discussed in order to emphasize the importance of solid management of HCD, which is one of the core tasks of a usability engineer. Usability engineering is a “discipline that provides structured methods for achieving usability in user interface design during product development”[28]. The main task of usability engineering is to plan processes, methods, timelines and resources. As the various disciplines in usability engineering and UX Design are complex and interwoven, this activity is decisive for the success of HCD and will ultimately determinewhether, in the end, the designed solution meets the specific user requirements. This is where the connection is drawn to the fields psychology, information technology and business administration studies.

2.8. Conclusion

At the end of the first term, the students are asked to document their solution for a “concept of an interactive system for students”. Each group presents their documented artifacts, approach, problem statement, ideation results and iterative prototype creation and evaluation in front of the class.In the course of the term, the students have thus been introduced to HCD, its terminology and activities and had a chance to put this knowledge into practice. This is meant as foundation for specialization in subsequent terms.

3. Outline for a curriculum for HCD at a design faculty – Terms 2 to 6

3.1. Prototyping, term 2

The focus of term 2 is on prototyping in a graphical (user interface design), technical (front end development) and human (interaction design) sense. As a conceptual foundation of the three aspects, certain topics will be addressed specifically, for example transitions & animations: the more high-fidelity the prototype becomes, the more emphasis needs to be put on transitions and animations. Transitions describe the effect when switching from one part of the system to another, while animations are used on UI component level. Both effects can enable a non-verbal UI communication, giving the user feedback, hints or instructions without having to use text at all. Another topic tobe addressed is physical affordance, which deals with the properties of an object that inform people how the object could be used.Professional prototyping tools such as Axure RP [29] and contextual limitations of UI design in certain environments, like parallax effects when viewing a screen, are also discussed.Finally, methods such as co-

creation are introduced and excursions into topics such as gamification undertaken. All mentioned areas are connected with ergonomics and human factors studies, including knowledge exchange with respective faculties. In addition, programming courses are offered, including interdisciplinary practical tasks with informatics students.

3.2. User research, term 3

Term 3 is based on psychology, human factors and ergonomics, focusing on user research methods. Deriving user requirements from the user needs correctly according to HCD is also taken up. It is crucial for requirement engineering to have a stakeholder discussion and come to a decision about the various kinds of requirements, such as user, business or technical requirements. These requirements might be supportive, neutral or contradicting. The decision with regard to requirement prioritization and exclusion is a crucial step in the process without which all following steps wouldhave an unsteady foundation.In-depth Design Thinking activities such as ideation workshops and the use of metaphors and analogies will also take place. In the course of term 3, collaboration with psychology faculties is a crucial aspect to professional education in user research.

3.3. Usability evaluation, term 4

Building on term 3, the aspect of human factors engineering is taken further, focusing on usability evaluations. Firstly, quantitative methods are presented, focusing on the use, analysis and interpretation of standard questionnaires, such as the System Usability Scale [30] or the AttrakDiff[31]. Secondly, qualitative evaluation methods are taught in depth, with reference to usability lab tests, contextual test set-ups like field tests and tests in a re-built physical environment, using for example foam core.The emphasis is laid on professional preparation, execution and analysis of such tests, focusing on the correct behavior of the test moderator in practical exercises.

As term 5 is reserved for internships, the curriculum continues with term 6. Student internships are recommended to be served at companies or service providers, that focus on managing or creating interactive products, using approaches like HCD, DT or similar.

3.4. Usability engineering, term 6

Setting up and executing HCD in a realistic environment is at focus in term 6: Planning the approach, workflow and steps according to Human-Centered Design as well as the integration of HCD into existing software development and design processes are highlighted. The difference between Design Thinking and other HCD-related approaches and processes isdemonstrated, referring specifically to the aspect of innovation potential. In addition, professions such as usability engineer, usability tester, interaction designer, userinterface designer and user researcher are differentiated[32].The connection with information technology studies is demonstrated, with special reference to software development lifecycles and the integration of HCD. Business administration-related topics are also illustrated, such as the verification of usability engineering in businesses[33], the setting of usability engineering KPIs[34], the use of HCD maturity models and the presentation of change management as a means of introducing HCD into company procedures.

4. Summary, research limitations and future research

After having completed their studies, the students will have a thorough understanding ofhow to executeHCD activities and methods and will have first experience to plan HCD in a realistic environment. To be able to work in multidisciplinary teams, the students were introduced to related topics in the fields of psychology, information technology and business administration. In order to validate the draft of a curriculum for multidisciplinary application, the first term lessons are to be put into practice at the design and media engineering faculties of the University of Applied Sciences Nuremberg Georg Simon Ohm. In addition, certain research limitations and future research needs to be addressed. Although the foundation of the curriculum is taken from ISO 9241 as the international standard, alternative definition frameworks in the HCI field should be researched further. An in-

depthexamination of Human-Computer Interaction curricula in the fields of psychology & human factors, information technology, business administration, design and related studies is also considered beneficial. An analysis of similarities and contradictions between differing fields of study would seem to be a necessary validation of the above-described curriculum.

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